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(71) Applicant: N.V. Philips' Gloeilampenfabrieken
Groenewoudseweg 1
NL-5621 BA Eindhoven(NL)

(72) Inventor: Stegehuis, Herman
c/o INT. OCTROOIBUREAU B.V. Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

(74) Representative: Zwaan, Andries Willem et al
INTERNATIONAAL OCTROOIBUREAU B.V.
Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

(54) X-ray examination apparatus.

(57) A contour is determined in the X-ray image by means of an image processing unit (13) in an X-ray examination apparatus (2,5) so that arithmetic means (16) can determine the position of absorbing diaphragm slats (24,25;26,27) which enclose a minimum area situated around the contour. The diaphragm slats are moved to the correct position by way of a drive unit (17). As a result, overexposure of the X-ray image intensifier tube (5) is counteracted and the medical details in the image become more distinct. Image harmonization can be realised by using X-ray absorbing wedges (43-46), arrangement of the wedges in excessively light parts of the X-ray image enables the dynamic range to be increased at areas of interest. The position of the wedges is calculated on the basis of a dose calculation based on an exposure time and the voltage and current applied to the X-ray source (2), said quantities being applied to the arithmetic means *via* a control unit (15).

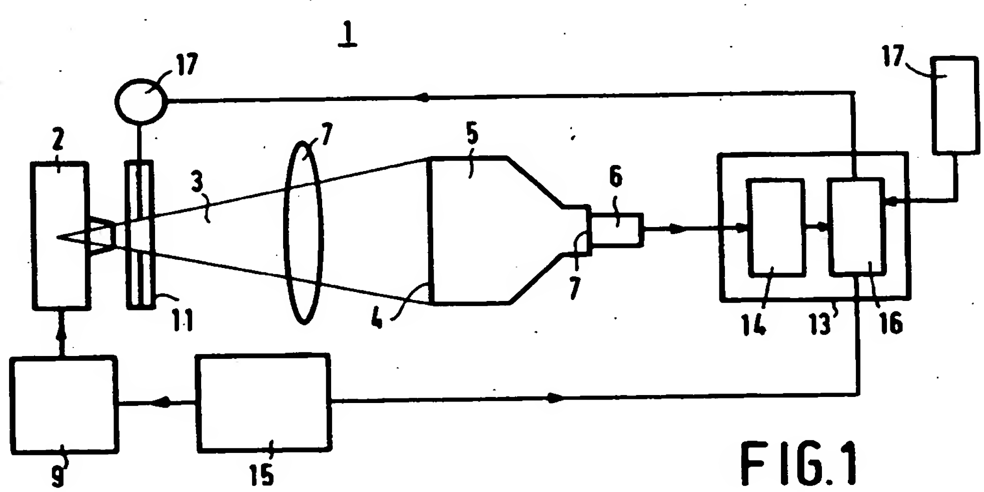

FIG.1

EP 0 496 438 A1

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The invention relates to an X-ray examination apparatus, comprising an X-ray source for emitting an X-ray beam, an X-ray detector which is arranged so as to face the X-ray source and which serves to form an X-ray image of an object to be arranged between the X-ray source and the X-ray detector, a power supply system which is connected to the X-ray source for the supply of current and voltage to the X-ray source, absorption means which can be arranged between the X-ray source and the X-ray detector in order to attenuate the X-ray beam, and an image processing unit which is connected to the X-ray detector in order to store the X-ray image as absorption values arranged in a matrix.

An X-ray examination apparatus of this kind is known from European Patent Specification EP-B1-157 688.

The cited Patent Specification discloses that a substantial difference in contrast can occur in an X-ray image formed by exposure of an object to X-rays. These brightness differences in an X-ray image can arise because a part of the X-rays does not penetrate the object to be examined and is incident directly on the X-ray detector, or because the object to be irradiated exhibits substantial differences in respect of absorption. For example, when in medical diagnostics an organ exhibiting a high absorption, for example a heart, is surrounded by organs which are compartively transparent to X-rays, for example lungs, an X-ray image is obtained in which the contrast within the organ of interest is low in comparison with the contrast between the brightest and the darkest areas in the overall X-ray image. In order to make the dynamic range of the X-ray image coincide as well as possible with the contrast between the brightest and the darkest areas in the organ of interest, absorption means are arranged in known manner between the X-ray source and the object to be irradiated. To this end, there is made a first X-ray exposure which is projected as an optical image onto the object, *via* an X-ray image intensifier, a television camera device which cooperates with an exit window of the X-ray image intensifier, and a projection device. Subsequently, the absorption means, having an optical absorption proportional to their absorptive power for X-rays, are manually introduced into the light beam of the projected X-ray image, thus achieving a desired reduction of the dynamic range of the X-ray image. Such a method for positioning the absorption means necessitates the use of an additional projection device, increasing the complexity of the X-ray examination apparatus, and is comparatively cumbersome because of the manual operations involved. Moreover, because of the difference in interaction of X-rays and light with matter, a desired X-ray attenuation is merely approximated when the absorption means occupy a position producing a desired optical attenuation.

It is an object of the invention to provide an X-ray examination apparatus in which the absorption means are accurately positioned and overexposed areas in the X-ray image are reduced. It is another object of the invention to provide an X-ray examination apparatus in which a contrast in an X-ray image is accurately limited to predetermined limits. To achieve this, an X-ray examination apparatus in accordance with the invention is characterized in that the image processing unit comprises detection means for detecting sub-areas in the X-ray image within which the absorption values are below a predetermined threshold value, and arithmetic means for calculating a position of the absorption means in which they increase the absorption values in the sub-areas of the X-ray image to a predetermined value, the image processing unit being connected to a drive unit for displacing the absorption means to the position calculated by the image processing unit.

The invention is based on the recognition of the fact that, when a part of the X-ray beam is incident on the X-ray detector without having penetrated an object arranged between the X-ray source and the detector, the X-ray image will comprise a distinct contour within which a projection image of the irradiated object is visible and beyond of which the X-ray image is overexposed. Automatic detection of this contour is realised, for example by determining the gradient in each point of the X-ray image or by image segmentation on the basis of a threshold value, the threshold value being, for example a fraction of the maximum absorption value. *Via* detection of the contour, the position of the absorption means in the X-ray beam can be calculated in which the overexposed areas in the X-ray image are masked, after which this position can be automatically adjusted. The visibility of the relevant details is thus improved, because the overexposed areas can no longer detract an observer and because on average the scattered radiation is less because of the reduction of the X-ray beam. When an X-ray image intensifier is used as the X-ray detector, the "veiling glare" in the image intensifier and the optical system decreases when the absorption means are suitably positioned. The "veiling glare" is caused by scattered X-rays and scattered electrons and photons in the X-ray image intensifier and appears as a veil across the X-ray image. Besides the positioning of the absorption means outside the contour in the X-ray image, it is usually advantageous to enhance the contrast of sub-areas situated within the contour of the X-ray image by reducing the dynamic range of the sub-areas relative to one another. To this end, sub-areas which are too light can again be automatically determined and the position of an absorption member having a locally varying absorption, for example a radiation-absorbing wedge, can be automatically adjusted. This adjustment can be accurately performed by

calculation of the overall absorption of the object and the absorption means.

By automatic positioning of the absorption means which may fully absorb or partly transmit X-rays, the positioning in the first case being based on contour determination and in the second case on absorption calculation, optimum adjustment for these means can be quickly obtained. This enhances the ease of operation of the X-ray examination apparatus and the quality of the X-ray images.

An embodiment of an X-ray examination apparatus in accordance with the invention is characterized in that the absorption means are substantially non-transparent to X-rays, the detection means comprising a contour calculation unit for calculating a contour of a sub-area in the X-ray image, the arithmetic means being suitable for calculating a smallest projection of the absorption means in the X-ray image within which the contour is situated.

The position in which the absorption means enclose the smallest X-ray beam can be determined by calculating, using the arithmetic means and for different positions of the absorption means, the projection of the absorption means in the X-ray image where the projection is situated fully outside the contour. This is the optimum position of the absorption means, which optimum position is adjusted *via* the drive unit.

An embodiment of an X-ray examination apparatus in accordance with the invention is characterized in that the absorption means comprise a first pair of slats having parallel, straight sides and being situated in a first plane extending transversely of the X-ray beam, said slats being translatable in the first plane in a direction transversely of the sides and being rotatable together in the first plane about an axis of rotation, and also comprise a second pair of slats having parallel, straight sides and being situated in a second plane which extends parallel to the first plane, said second pair of slats being translatable in the second plane in a direction transversely of the sides and being rotatable about the axis of rotation in the second plane.

An optimum position of the absorption means is found, for example by determination, in the X-ray image, of points of intersection of the contour and a first line extending through the centre of the X-ray image, the points of intersection being given by coordinates in the matrix of absorption values stored in the image processing unit. For a second line extending through a point of intersection found and perpendicularly to the line through the centre and the relevant point of intersection, it is determined whether it intersects or is tangent to the contour in a further point. If the contour is intersected by the second line, the same procedure is repeated for a further line which extends parallel to the second line but which is situated nearer to the edge of the image; this is continued until the line is found which extends perpendicularly to the first line and which is tangent to the contour without intersecting the contour. Thus, for different angular positions of the first line through the centre pairs of parallel tangents are calculated which extend perpendicularly to the first line and which are tangent to the contour. By determination of the two pairs of tangents enclosing the smallest area, the position of the absorption means in which the projection of the sides of the slats coincides with the tangents found is found as the optimum position of the absorption means. The drive unit rotates the absorption means through the angle which is equal to the angle of the normal to the tangent pairs found in the coordinate system defined by the image matrix, the translation of the slats by the drive unit being proportional to a distance between the line pairs and the centre of the X-ray image.

A further embodiment of an X-ray examination apparatus in accordance with the invention is characterized in that the absorption means comprise a circular diaphragm.

In that case an optimum position of the absorption means is determined, for example by the smallest circle circumscribing the contour in the X-ray image and having the centre of the X-ray image as its centre.

A further embodiment of an X-ray examination apparatus in accordance with the invention, in which the absorption means comprise an absorption member exhibiting a locally varying absorption, is characterized in that the power supply system is connected to a control unit for adjusting the voltage and current generated by the power supply system during an exposure time, the image processing unit being connected to the control unit in order to receive the adjusted exposure time value, the voltage value and the current value, and to apply these values to the arithmetic means in order to determine the position of the absorption means.

On the basis of the current and the voltage in the X-ray source and the exposure time, the energy fluence of the X-rays emitted by the X-ray source can be calculated in the control unit. During irradiation of the object, the X-ray beam is attenuated by interaction with the atoms in the object, which interaction may be a photoelectric effect or a Compton or Rayleigh scattering. An X-ray which is not detected by the X-ray detector after scattering contributes to the contrast in the X-ray image, whilst an X-ray which is detected after scattering adversely affects the contrast. The scattering of X-rays is dependent on the thickness of the irradiated object. Due to the scattering, for the energy fluence detected by the detector it holds that:

$$\phi_d : \phi_o k(x) e^{-\mu x} \qquad (1)$$

where x is the thickness of the irradiated object, ϕ_o is the energy fluence from the source, and μ is the linear attenuation coefficient for X-rays. The factor k(x) represents the contribution of the scattered X-rays to the detected energy. The factor k(x) is dependent on the object thickness x, on the geometry of the X-ray examination apparatus, and on the possible presence of a scatter grid in front of the X-ray detector. Using the formule (1), the thickness of the irradiated object can be calculated from the measured energy fluence ϕ_d and from ϕ_o which is calculated from the exposure time and the voltage and current applied to the X-ray source. Subsequently, the overall thickness of the object and the absorption means for which a desired attenuation occurs in the X-ray image can be calculated. Because the scattering of the X-rays in the absorption means is also determined by this calculation, the effect of the position of the absorption means on the contrast in the X-ray image is comparatively accurately known.

Some embodiments of an X-ray examination apparatus in accordance with the invention will be described in detail hereinafter, by way of example, with reference to the accompanying drawing. In the drawing:

Fig. 1 shows an X-ray examination apparatus 1 for medical diagnostic applications, for example fluoroscopy or angiography. From a focus an X-ray source 2 generates a beam of X-rays 3 which is incident on an X-ray detector 5. Due to absorption differences in an object 7, the X-ray beam is locally intensity modulated so that a projection image of the object 7 appears on an entrance screen 4 of the X-ray detector 5. The X-ray detector 5 is in this case an X-ray image intensifier in which X-rays produce light in an entrance screen consisting of CsI, so that the X-ray image is converted into an optical image. In a photocathode the optical image releases electrons which are accelerated to, for example 20 keV by means of an electrode system and which are focused on an exit screen 7 of the X-ray image intensifier 5 on which a phosphor layer is provided. A reduced and brightness-intensified image of the entrance screen 4 of the X-ray image intensifier 5 appears on the exit screen 7. *Via* a television camera tube 6 which cooperates with the exit screen 7 of the X-ray image intensifier 5, the optical image is converted into an electric signal which is applied to an image processing unit 13. In the image processing unit 13 the signals from the television camera tube 6 are digitized and stored in the form of a matrix of grey values. In the X-ray image detection means 14 determine a contour beyond which the grey values exceed a given threshold value. The arithmetic means 16 calculate a position of the absorption means 11 in which the area outside the contour in the X-ray image is masked as well as possible by the absorption means 11. The arithmetic means 16 subsequently control drive means 17 to move the absorption means 11, in this case absorbing the X-rays completely, to the desired position. In addition to the limitation of the X-ray beam 3 by the absorption means 11, it may be desirable to introduce absorption means 11 into the beam so as to attenuate the beam at predetermined locations. To this end, the arithmetic means 16 are connected to a control unit 15 which controls a power supply system 9 and which adjusts an exposure time, voltage and current of the X-ray source 2. The arithmetic means 16 can receive, for example *via* a keyboard 17, information concerning the distance between the focus of the X-ray source 2 and the entrance screen 4, the image reduction factor of the X-ray image intensifier 5, and the aperture of a diaphragm (not shown in the Figure) arranged between the exit screen 7 and the television camera tube 6. On the basis of *inter alia* the exposure time, the voltage and the current in the X-ray source 2, the arithmetic means 16 calculate a desired position of the absorption means 11 which in this case comprise, for example a perspex wedge.

Fig. 2 diagrammatically shows the absorption means 11, an iris diaphragm 22 and lead slats 24,25, 26 and 27 being mounted in a housing 20. The drive unit 17 is formed by four step motors 17a, 17b, 17c, 17d. *Via* a step motor 17a, the lead slats 24 and 25 can be displaced together in the direction of the axis 29, in this case the position of the lead slats 24 and 25 being symmetrical with respect to the axis 29. *Via* a step motor 17b, driving a rotary member 31 *via* a gear wheel 30, the lead slats 24 and 25 can be rotated about the axis 29. The same holds for the lead slats 26 and 27.

Fig. 3 shows an X-ray image of a hand, the areas situated outside the contour 32 being overexposed because the X-rays are incident on the X-ray image intensifier 5 without having been attenuated. When the lead slats 24, 25, 26 and 27 are arranged in the positions shown, in which in the present example a distance from an image centre 34 is the same for the masking lead slats 24, 25, 26 and 27, overexposure is substantially prevented. When the lead slats 24, 25, 26 and 27 are independently displaceable with respect to the image centre 34, a position of the lead slat 26 along a line 36 is optimum. In this case a step motor 17 is provided for displacement of each lead slat.

Fig. 4 diagrammatically illustrates the calculation of an optimum position of the lead slats 24, 25, 26 and 27 by means of the arithmetic means 16. After determination of the contour 32 in the digital image matrix 40 by the contour calculation unit, the intersection with the contour 32 is determined along a line ℓ which extends through the image centre 34 and which encloses an angle α with respect to the x-axis. From the

points of intersection 35 and 36 it is determined, along a line extending perpendicularly to ℓ, whether more than one point of the contour is situated on this line. If so, this operation is repeated for a further line which extends perpendicularly to ℓ but which is situated nearer to an edge of the image. Thus, the positions of the lead slats 24 and 25 are found. The same procedure can be followed for a line m which encloses an angle β with respect to the x-axis, resulting in the positions of the lead slats 26 and 27. The area enclosed by the lead slats in this position is given by q.p. sin (β - α). Therein, q and p are the length of the sides of the rhombic projection of the lead slats 24, 25, 26 and 27. By calculating the surface area at a given angle β for a number of (for example, 90) angles α, a setting can be found for the lead slats 24, 25, 26 and 27 in which the surface area is minimum. After the smallest surface area has been found, the lead slats are rotated through the desired angles α and β about the axis 29, after which they are displaced with respect to the centre of the X-ray image.

Fig. 5 shows the absorption means 11, the lead slats being replaced by absorption members 43, 44, 45 and 46 having a varying absorption, for example perspex wedges. The rotation of the wedges 43, 44, 45 and 46 about the axis 29 can be coupled, so that one of the step motors 17b and 17d for driving the rotation can be dispensed with. These absorption means enable elimination of differences in intensity of sub-areas situated within the contour 32 as shown in the Figs. 3 and 4. To this end, the arithmetic means 16 of the image processing unit 13 calculate the energy fluence ϕ_o from the preset values of the exposure time, the voltage and the current of the X-ray source as:

$$\phi_o(df) = 36\ J\ .\ tirr\ .\ (T/100)^{2.1}\ /\ df^2 \qquad (2)$$

Therein:
- df is the distance between the point at which the energy fluence is observed and the focus of the X-ray source 2 in m;
- tirr is the exposure time in s;
- J is the current from the cathode to the anode in the X-ray source in mA;
- T is the maximum voltage at which the electrons in the electron source are accelerated in kVp;
  ϕ_o is given in $nJmm^{-2}$

Without taking into account scattered radiation, after irradiation of an object having a thickness x_p and an absorption coefficient μ (m^{-1}) the energy fluence ϕ_d on the detector is:

$$\phi_d\ (df) = \phi_o\ (df)\ e^{-\mu x_p} \qquad (3)$$

Using this formule, the thickness x_p of the irradiated object can be found by substitution of the value for ϕ_o - (df) found by way of the formule (2). When the absorption values are too low within a sub-area of the X-ray image and the energy fluence on the detector is to be reduced to ϕ_o' (df) by way of a filter having a thickness x_f, the filter thickness is simply found from the relation:

$$\phi_d'\ (df) = \phi_o\ (df)\ e^{-\mu p\ xp\ -\ \mu f\ xf} \qquad (4)$$

The dynamic range of the X-ray detector can be more effectively used by translation of an absorbing wedge in the X-ray beam to the position in which the projection of the part of the wedge having a thickness X_f coincides with the excessively bright sub-area in the X-ray image.

Using a simple model for X-ray attenuation by an object as described above, the relation between the energy fluence detected by the detector and the thickness of the irradiated object usually cannot be determined sufficiently accurately. The dependency of the attenuation coefficient μ on the acceleration voltage of the X-ray source, scattered radiation effects and possible presence of a scatter grid between the irradiated object and the X-ray detector have an effect on the energy fluence measured by the detector. The attenuation coefficient μ can be written as:

$$\mu = t + s \qquad (5)$$

Therein, t is the contribution by the photoelectric effect to the attenuation and s is the contribution by the scattering to the attenuation. s is constant, whilst t may be written as:

$$t = t_{ref}\ .\ (T/E_{ref})^{-2.75} \qquad (6)$$

Therein, t_{ref} is a calibration value of the attenuation due to the photoelectric effect for the energy E_{ref}, the

values amount to, for example: t_{ref} = 0.0008 m^{-1} for E_{ref} = 100 KV. Furthermore, between the source and the object to be irradiated prefiltering takes place by means of Al of Cu filters in order to filter the low-energetic X-rays which do not contribute to imaging out of the X-ray beam. When an object is irradiated, the absorption of the low-energetic X-rays in the object is greater than the absorption of the high-energetic X-rays, so that the mean energy of the X-ray beam increases as the object is penetrated further by the X-rays (beam hardening). A formule which comparatively accurately describes the energy fluence ϕ_o behind a number of i irradiated objects (filters, object to be examined, etc.) is as follows:

$$\varphi_p\ (df) = \varphi_o\ (df)\ \exp[-3.2\ (\sum_i t_i x_i)^{0.63} - \sum_i s_i x_i - 0.3] \quad (7)$$

wherein x_i is the thickness of a material i in the direction of irradiation and df is the distance between the point at which the energy fluence ϕ_o is observed and the focus of the X-ray source. The suffix p indicates that the primary radiation is concerned, *i.e.* the non-scattered radiation. In addition to primary radiation, scattered radiation also contributes to the energy fluence on the X-ray detector. A contribution by Rayleigh scattering, where the X-ray quanta are scattered without loss of energy through small angles, is given by:

$$\phi_r\ (di) = \phi_p\ (di)\ x_p\ \sigma r\ (\sin \phi_m)^{Er} \quad (8)$$

Therein:

- ϕ_r is the energy fluence of the Rayleigh scattered X-ray quanta in nJ mm^{-2};
- di is the distance between the focus of the X-ray source 2 and the entrance screen of the X-ray image intensifier tube 5;
- x_p is the thickness of the irradiated object in m;
- σr is the linear interaction coefficient for Rayleigh scattering, for example 0.002 m^{-1};
- ϕ_m is the angle between the object edge and the centre of the X-ray detector; and
- Er is an experimentally determined constant value, for example Er = 0.2.

The model on which the formule (8) is based is a flat, homogeneous disc having an absorption equal to the absorption of water.

The following formule holds for Compton scattered X-rays where a loss of energy of the X-rays occurs:

$$\phi_c\ (dp) = \phi_p\ (dp)\ 1/2\ s^2\ x_p\ G/(s + at) \quad (9)$$

Therein, dp is the distance between the focus of the X-ray source 2 and the point at which the Compton radiation emerges from the irradiated object 7. The factor 1/2 appears for thin objects, because Compton scattering is emitted to two sides. G is an experimentally determined factor which depends on the ratio of the thickness to the transverse dimension of the irradiated object and has a value of between 0.5 and 2.0, a being an experimentally determined constant term for which: a = 0.6. For the Compton radiation ϕ_c (di) reaching the X-ray detector the following is found:

$$\phi_c\ (di) = \phi_c\ (dp)\ \sin^2\ (\phi_m) \quad (10)$$

The factor $\sin^2$ (ϕ_m) is introduced because the Compton scattered X-rays leave the irradiated object, from the surface facing the X-ray detector, with an angular distribution which is given by cos(ϕ). Therein, ϕ is the angle enclosed by the ray 1 in Fig. 6, extending between the surface emitting the Compton radiation and the centre of the X-ray detector 5 with respect to the axis through the centre of the X-ray detector. Integration over the disc-shaped proposed surface produces the term $\sin^2$ (ϕ_m).

From the formules (7), (8) and (9) it follows for the energy fluence ϕ_s (di) of the scattered X-rays on the detector that:

$$\varphi_s\,(di) = \varphi_c\,(di) + \varphi_r\,(di) = \varphi_c\,(dp)\,\sin^2(\varphi_m) + \varphi_p\,(di)\,.\,x_p\,(\sin\varphi_m)^{Er}$$

$$\varphi_s\,(di) = \varphi_p\,(dp)\,1/2\,s^2\,x_p\,G\,\sin^2(\varphi_m)/(s + at) + \varphi_p\,(di)\,.\,x_p\,(\sin\varphi_m)^{Er} \qquad (11)$$

where $\phi_p\,(dp)/\phi_p\,(di) = di^2/dp^2$, because of the inverse square attenuation, is applicable with (11):

$$\phi_s\,(di)/\phi_p\,(di) = 1/2\,s^2\,x_p\,G\,\sin^2(\phi_m)\,(di^2/dp^2)/(s + at) + x_p\,(\sin\phi_m)^{Er} \qquad (12)$$

The radiation detected by the X-ray detector can be described as:

$$\varphi_d\,(di) = \varphi_p\,(di) + \varphi_s\,(di) = \varphi_p\,(di)\,(1 + \varphi_s\,(di)/\varphi_p\,(di))$$

$$\varphi_d\,(di) = k(x_p)\,\varphi_p\,(di) \qquad (13)$$

Solution of the formule (13), for example by iterative adaptation of the object thickness x_p, produces the thickness of the object x_p, after which the thickness of the absorption means required in order to obtain the desired attenuation can be calculated. When the desired thickness of the absorption means is known for the excessively light sub-areas in the X-ray image, the absorption means are translated and rotated by the displacement means 17 so that the projection of the part of the absorption means exhibiting the desired thickness is coincident with the relevant sub-area. It will be evident that the absorption means shown in Fig. 2 and in Fig. 5 can also be simultaneously used, the absorption means 24-27 and 43-46 then preferably being accommodated in the same housing 20.

Claims

1. An X-ray examination apparatus, comprising an X-ray source (2) for emitting an X-ray beam (3), an X-ray detector (5) which is arranged so as to face the X-ray source (2) and which serves to form an X-ray image of an object (7) to be arranged between the X-ray source and the X-ray detector, a power supply system (9) which is connected to the X-ray source for the supply of current and voltage to the X-ray source (2), absorption means (11) which can be arranged between the X-ray source (2) and the X-ray detector (5) in order to attenuate the X-ray beam, and an image processing unit (13) which is connected to the X-ray detector in order to store the X-ray image as absorption values arranged in a matrix, characterized in that the image processing unit (13) comprises detection means (14) for detecting sub-areas in the X-ray image within which the absorption values are below a predetermined threshold value, and arithmetic means (16) for calculating a position of the absorption means (11) in which they increase the absorption values in the sub-areas of the X-ray image to a predetermined value, the image processing unit (13) being connected to a drive unit (17) for displacing the absorption means (11) to the position calculated by the image processing unit (13).

2. An X-ray examination apparatus as claimed in Claim 1, characterized in that the absorption means (11) are substantially non-transparent to X-rays, the detection means (14) comprising a contour calculation unit for calculating a contour of a sub-area in the X-ray image, the arithmetic means (16) being suitable for calculating a smallest projection of the absorption means (11) in the X-ray image within which the contour is situated.

3. An X-ray examination apparatus as claimed in Claim 2, characterized in that the absorption means (11) comprise a first pair of slats (24), (25) having parallel, straight sides and being situated in a first plane extending transversely of the X-ray beam, said slats being translatable in the first plane in a direction transversely of the sides and being rotatable together in the first plane about an axis of rotation (29), and also comprise a second pair of slats (26), (27) having parallel, straight sides and being situated in a

second plane which extends parallel to the first plane, said second pair of slats (26), (27) being translatable in the second plane in a direction transversely of the sides and being rotatable about the axis of rotation in the second plane.

4. An X-ray examination apparatus as claimed in Claim 2, characterized in that the absorption means (11) comprise a circular diaphragm (22).

5. An X-ray examination apparatus as claimed in any one of the preceding Claims, in which the absorption means (11) comprise an absorption member (43), (44), (45), (46) exhibiting a locally varying absorption, characterized in that the power supply system (9) is connected to a control unit (15) for adjusting the voltage and current generated by the power supply system during an exposure time, the image processing unit (13) being connected to the control unit (15) in order to receive the adjusted exposure time, the voltage value and the current value, and to apply these values to the arithmetic means in order to determine the position of the absorption means.

6. An X-ray examination apparatus as claimed in Claim 5, in which the absorption members are shaped as a wedge, characterized in that absorption members can be arranged in two planes extending transversely of the X-ray beam.

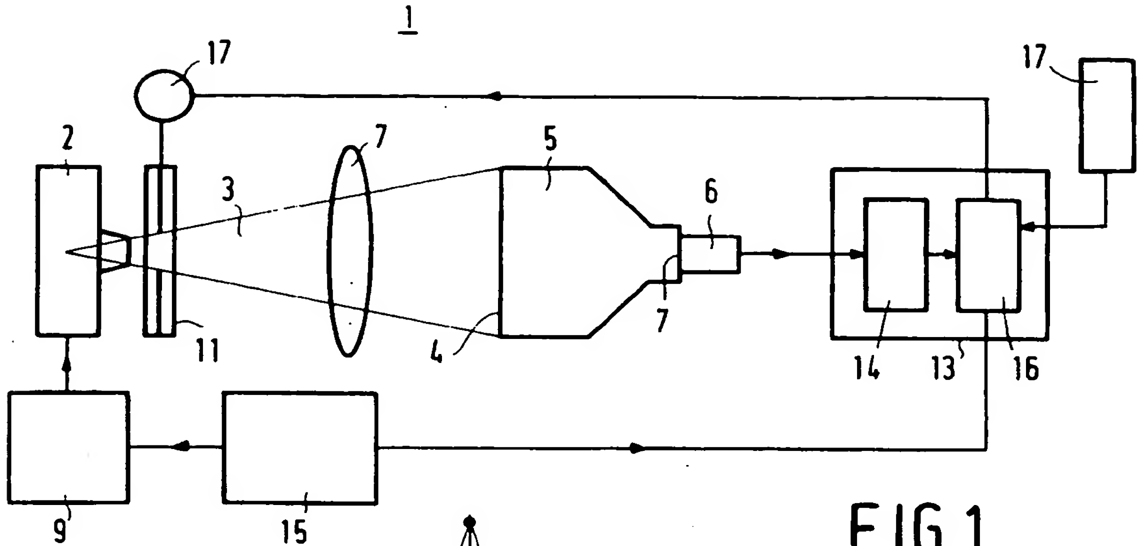

FIG.1

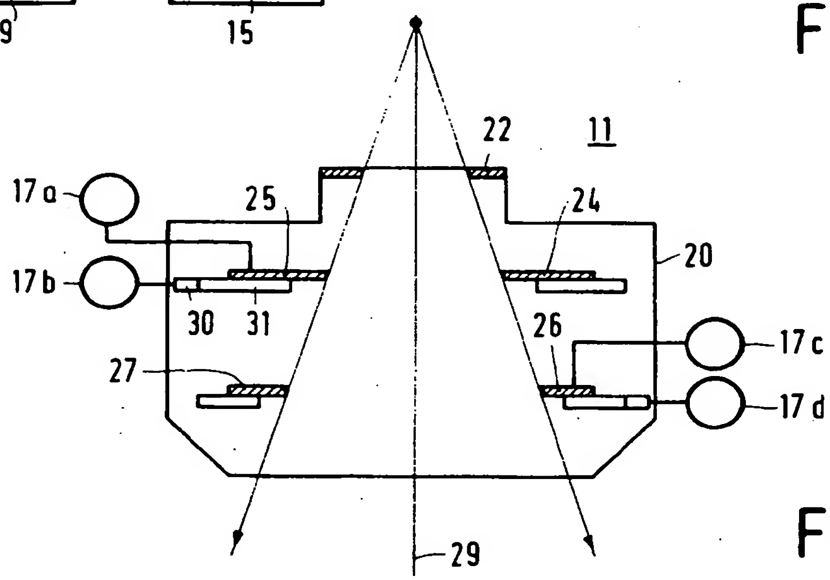

FIG.2

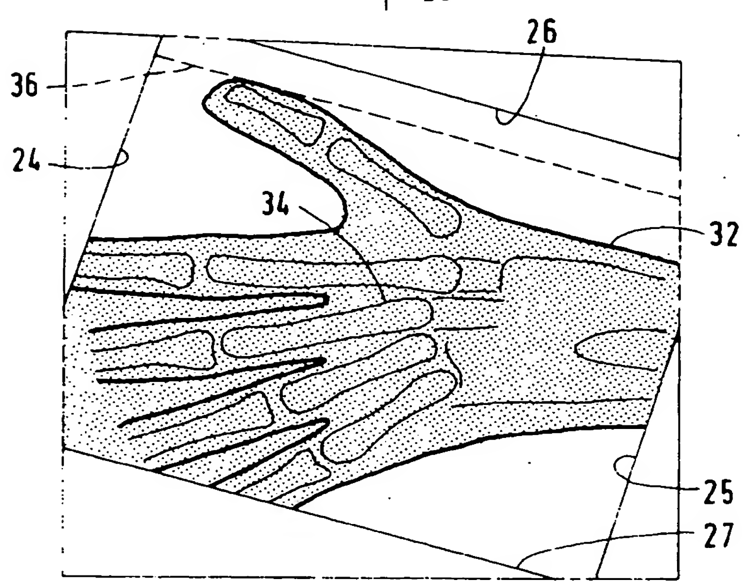

FIG.3

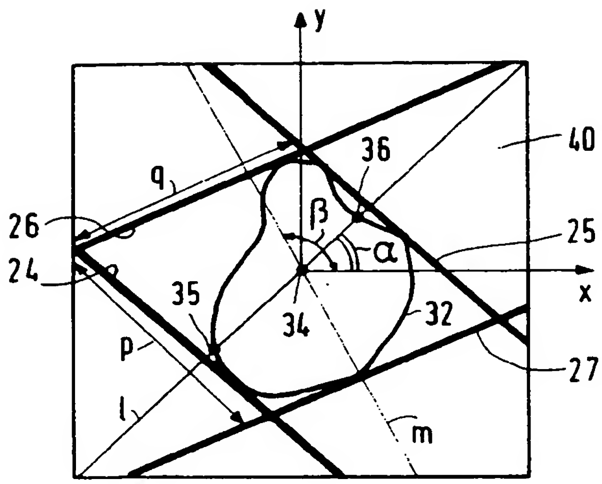

FIG.4

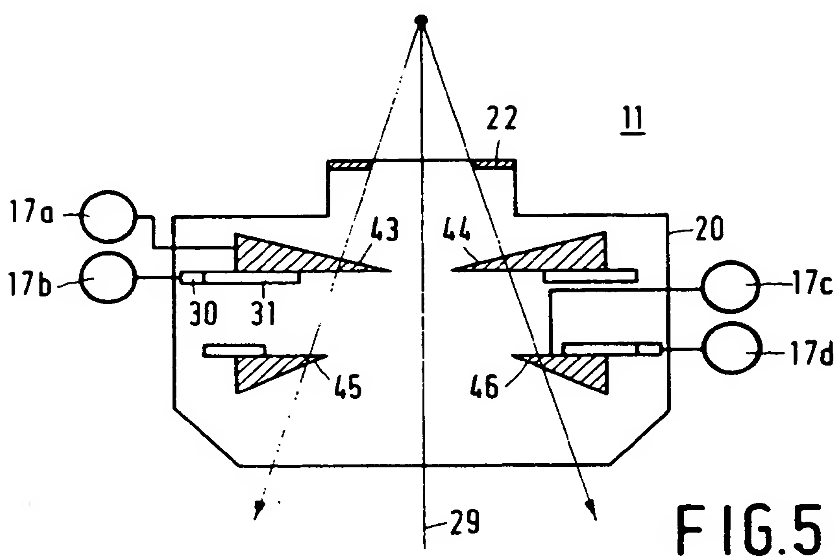

FIG.5

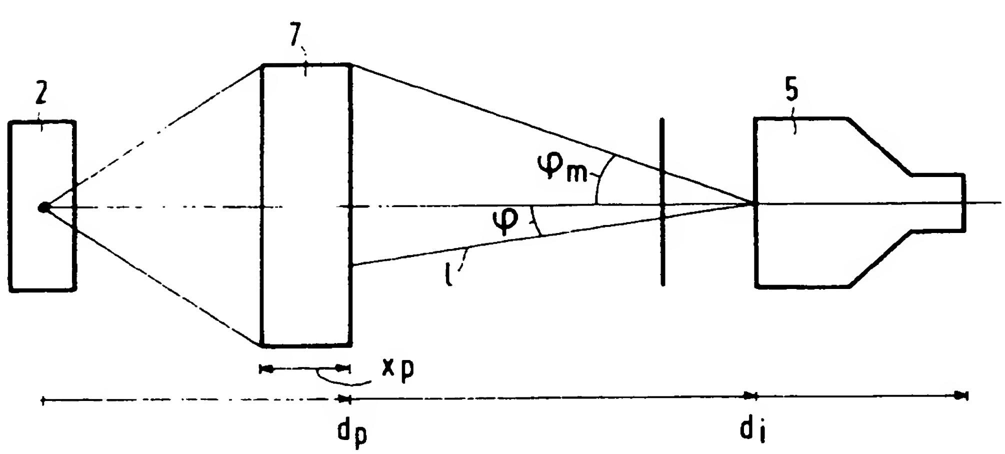

FIG.6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 20 0007

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-A-3 621 868 (SIEMENS A.G.) * column 4, line 15 - line 61; figure 2 * ---	1-3,5,6	A61B6/06 A61B6/03
X Y	US-A-3 755 672 (P. EDHOLM ET AL.) * column 4, line 59 - column 8, line 32 * * column 9, line 3 - line 64; figures 1-5 * ---	1,2 3-6	
X Y	DE-A-2 924 423 (PHILIPS PATENTVERWALTUNG) * page 12, line 16 - page 13, line 13 * ---	1,2 5	
Y	EP-A-0 187 245 (SIEMENS A.G.) * column 1, line 45 - line 66; figures * -----	3-6	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

A61B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 MARCH 1992	RIEB K.D.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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